



Exploration EVA System

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Exploration EVA System

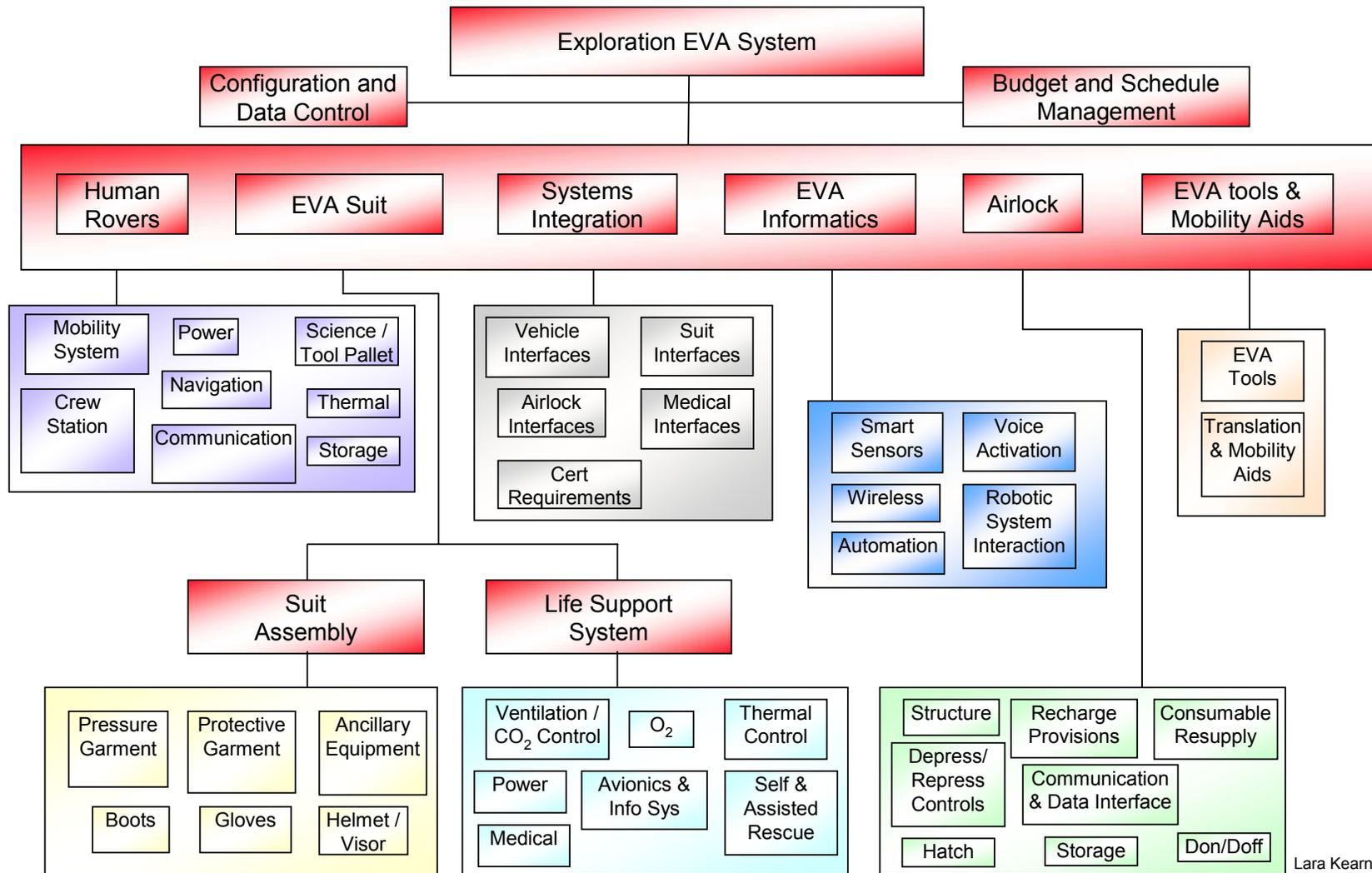


- In January 2004, the President announced a new Vision for Space Exploration
- NASA's Office of Exploration Systems has identified Extravehicular Activity (EVA) as a critical capability for supporting the Vision for Space Exploration
- EVA is required for all phases of the Vision, both in-space and planetary
- Supporting the human outside the protective environment of the vehicle or habitat and allowing him/her to perform efficient and effective work requires an integrated EVA "System of systems"
- The EVA System includes EVA suits, airlocks, tools and mobility aids, and human rovers
- At the core of the EVA System is the highly technical EVA suit, which is comprised mainly of a life support system and a pressure/environmental protection garment
- The EVA suit, in essence, is a miniature spacecraft, which combines together many different subsystems such as life support, power, communications, avionics, robotics, pressure systems and thermal systems, into a single autonomous unit
- Development of a new EVA suit requires technology advancements similar to those required in the development of a new space vehicle
- A majority of the technologies necessary to develop advanced EVA systems are currently at a low Technology Readiness Level of 1-3
 - This is particularly true for the long-pole technologies of the life support system



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Current State of EVA



Existing NASA EVA architecture is over 25 years old (1977) and has evolved from Apollo, Skylab and Shuttle technology and operations

All current EVA systems use large amounts of crew time and vehicle resources; require costly regular ground based maintenance, resupply, and monitoring; and are only compatible with low earth orbit, zero-gravity activities



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Summary of Existing Architecture Challenges



environment	<ul style="list-style-type: none"> • Suit mass, mobility, visibility and comfort are not compatible with partial gravity planetary environments; Inertial control and useful work/reach area in zero gravity is hampered • Suit protection from dust intrusion is inadequate • Available thermal insulation materials either only work in vacuum conditions or are thick and impede suit mobility and glove dexterity; Even with active heating, touch temperatures are limited to short durations and narrow ranges (-120 to +150F) • Radiation definition, monitoring and protection are inadequate beyond earth's ionosphere • Sensitive environments and science devices can be contaminated by suit by-products
productivity	<ul style="list-style-type: none"> • EVA information processing is limited to simple radio voice and suit/medical telemetry and is based on old technology that is not in-flight reprogrammable; No hands free display exists • Medical monitoring and treatment of EVA crew is minimal • Robotic EVA aids in use are primarily large arms with limited mobility and dexterity; Human rovers and mobile dexterous robots need additional attention; Most robotic aids are too reliant upon unique visual and handling aids • Tools are limited to manual force/torque reaction and zero-gravity transport/restraint; There is limited environmental and mechanical analysis; No drills; Few true repairs; Delicate materials not easily handled
logistics	<ul style="list-style-type: none"> • EVA overhead penalties are high in terms of mass, volume and time; 2600 lbs and 90 ft³ for suits, tools, carriers and consumables on STS-103 for HST; < 20 percent effective crew time • Suit consumables are expended and require frequent replenishment or considerable time/power to recharge; No in-situ resource utilization is possible • No suit maintenance capability beyond limited resizing, ORU replacement and consumables replacement • Airlock designs expend gas/power and are not compatible with dust containment



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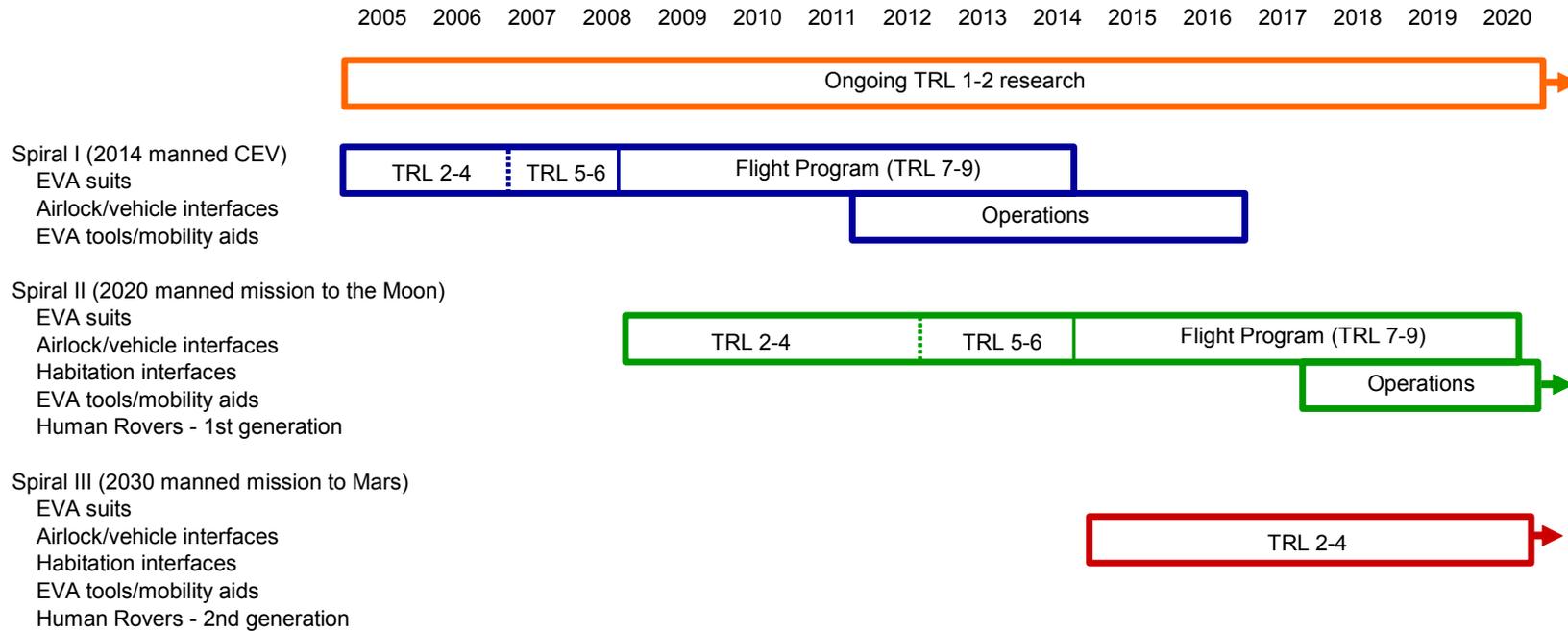
- **The Exploration EVA System should use revolutionary new technology, common components, human-robotic cooperation and a flexible architecture to support multi-destination operation with minimal system reconfiguration**
- **Features**
 - Lightweight, highly mobile suits and dexterous gloves to increase crew productivity, enable long-duration missions and high EVA use rates, mitigate crewmember injury and fit a wide range of crewmember sizes
 - Maintainable life support system architecture that is easily reconfigurable to enable multiple destinations
 - Integrated human-robotic work capability to increase safety, efficiency, & productivity
 - State of the art communications and computing capability for multi-media crew-ground interaction (e.g., integrated communications, high tech information systems, and heads-up displays)
 - Operating pressure regimes which decrease EVA overhead by drastically reducing or even eliminating pre-breathe protocols
 - Advanced thermal control to increase crew comfort, decrease consumables, and enable multiple destinations (e.g., aerogel insulation, active cooling and heating)
 - Common hardware with other vehicle systems to increase vehicle safety & decrease mission mass through common sparing (e.g., power, communication, instrumentation, life support, thermal control)



Exploration EVA System



- **The Exploration EVA System should follow a spiral development, in parallel with the CEV spirals**



EVA Core and Spiral I/2014 Technology

System Architecture

- ✦Flexible, lightweight, maintainable PLSS
- ✦Lightweight structures
- ✦Integral suit/PLSS interface
- ✦Rapid recharge and checkout

Thermal Control

- ✦Radiators
- ✦Micro refrigeration/heating system
- ✦Auto cooling control
- ✦Phase change materials
- ✦Thermal insulating materials
- ✦Conduction cooling garment

Power

- ✦Batteries
- ✦Fuel Cells

CO₂ Removal

- ✦Cyclic absorption/regeneration
- ✦Venting membranes

Interfaces

- ✦Human-robotic work aids
- ✦Airlock/vehicle
- ✦Crew Escape Systems
- ✦Bio-medical Sensors

Suits

- ✦Lightweight materials
- ✦Mobility systems
- ✦Gloves/Boots
- ✦Visors
- ✦Zero pre-breathe

Manufacturing Technology

- ✦Lightweight materials
- ✦Custom glove sizing

Electronics and Information

- ✦Heads-up display
- ✦Integrated high capacity communication
- ✦Smart systems monitoring, control, caution, & warning
- ✦High reliability fans, pumps, actuators, sensors

Spiral III/Mars Technology

CO₂ Removal

- ✦Laser CO₂ Decomposition
- ✦Cryogenic CO₂ Removal

Environmental Protection

- ✦Radiation protection
- ✦Dust containment and removal

Field Recharge & In-the-Field Servicing

- ✦O₂ connectors
- ✦Field serviceable packs
- ✦In-situ Resource Utilization

Interfaces

- ✦Human-robotic work aids
- ✦Manned rovers
- ✦Airlock/habitat
- ✦Bio-medical Sensors

Airlock

- ✦Lightweight structures
- ✦Reduced consumables

Spiral II/Lunar Technology

Environmental Protection

- ✦Dust containment and removal
- ✦Radiation protection

Field Recharge & In-the-Field Servicing

- ✦O₂ connectors
- ✦Field serviceable packs
- ✦In-situ Resource Utilization

Interfaces

- ✦Human-robotic work aids
- ✦Manned rovers
- ✦Airlock/habitat
- ✦Bio-medical Sensors

Airlock

- ✦Lightweight structures
- ✦Reduced consumables

Spiral N / Exploratory 0-G Technology

Environmental Protection

- ✦Radiation protection

Thermal

- ✦Venting hydride cooler
- ✦Venting cryogenic cooler

Interfaces

- ✦Human-robotic work aids

